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AMCHITKA BIOENVIRONMENTAL PROGRAM

AMCHITKA BIOLOGICAL INFORMATION SUMMARY

by

R. Glen Fuller

May, 1971

Prepared for the U. S. Atomic Energy Commission
under Contract No. AT(26-1)-171

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INTRODUCTION

Early in 1967, the United States Atomic Energy Commission, Nevada Operations Office (AEC/NVOO), began a detailed evaluation of Amchitka Island, in the western Aleutians, as a potential site for underground nuclear testing. As part of this evaluation, AEC/NVOO has maintained liaison with appropriate Federal and State agencies responsible for the fish and wildlife resources of Amchitka and its environs. The AEC has also sponsored a varied program of bioenvironmental investigations, both on the island and in the marine environment around it, under the technical management of Battelle's Columbus Laboratories.

In October, 1969, a "calibration" test, Project Milrow, was carried out on Amchitka. Milrow involved the detonation of a nuclear device of about 1 megaton yield, approximately 4,000 feet below the island surface. The effects of Milrow were studied and documented by a variety of pre- and postshot observations, testtime experiments, and physical measurements. Analysis of the Milrow-effects data led to the judgment that a test of somewhat higher yield could be safely carried out on the island. The AEC has, in fact, announced plans to conduct such a test, Project Cannikin, during the fall of 1971.

The AEC presence and activities on Amchitka Island (one of the islands of the Aleutian Islands National Wildlife Refuge) concern many individuals and organizations dedicated to conservation and preservation of environmental quality. This concern has generated a number of inquiries and publications concerning the potential effects of the AEC testing program on Amchitka ecosystems. Some of them reveal misunderstandings about the wildlife resources and ecological characteristics of the island. The present document presents a summary of information on the more important wildlife species and bioenvironmental features of Amchitka, and an evaluation of the influence of AEC activities on these features.

ALEUTIAN ISLANDS NATIONAL WILDLIFE REFUGE

The Refuge is managed by the Fish and Wildlife Service (FWS) of the U. S. Department of the Interior (USDI). Amchitka is one of some 200 islands comprising the Refuge, which stretches westward in a gentle arc, approximately 1,100 miles from Unimak Island just off the western tip of the Alaskan Peninsula, to Attu Island, 250 miles west northwest of Amchitka. (See Figure 1.) The islands vary widely in size, topography, wildlife, and extent of disturbance by modern man. Some of the islands, e.g., Shemya and Adak, are still occupied by American military forces. Others, like Amchitka, Attu, and Kiska, still bear the scars of military occupation during World War II. Only two islands in the Refuge (Atka and Unimak) have small native Aleut villages (USDI, 1966).

Unimak Island, the largest island in the Refuge, being very close to the tip of the Alaskan Peninsula, is inhabited by some of the large terrestrial mammals present on the peninsula, including the Alaskan brown bear and the caribou. Caribou have also been introduced onto Adak, and reindeer onto Atka. Other terrestrial mammals, such as wolves, wolverines, and foxes, are found in the eastern part of the Refuge, but none of these occurs on Amchitka.

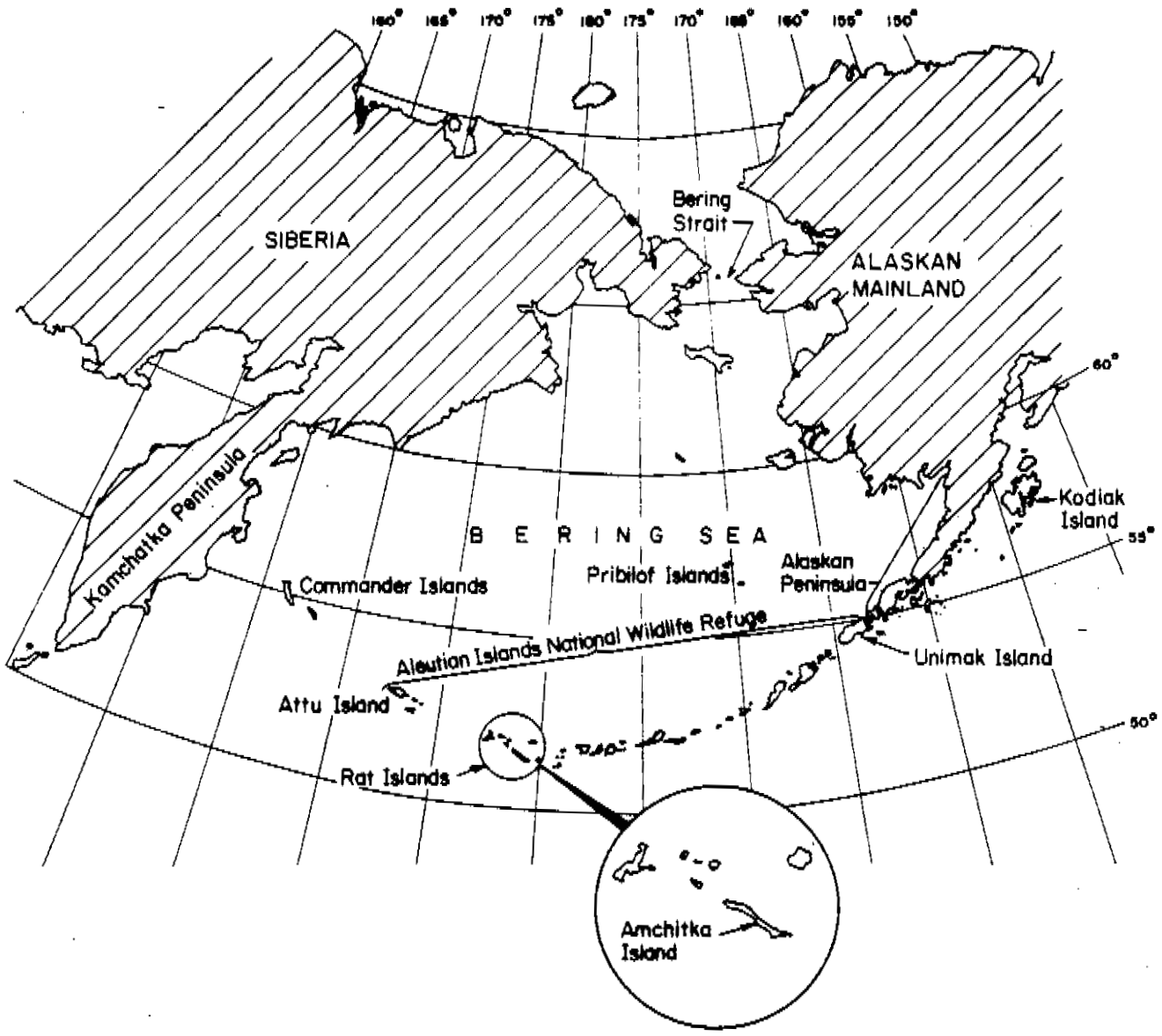

FIGURE 1. LOCATION OF AMCHITKA IN RELATION TO ASIAN AND NORTH AMERICAN MAINLANDS AND THE ALEUTIAN ISLAND CHAIN

With the exception of the Norway rat, which was inadvertently introduced during World War II (Murie, 1959), and which has resisted all attempts at eradication, no terrestrial mammals are presently known to occur on Amchitka. So far as is known, none of the biotic elements found on Amchitka is unique to that island. However, ecological studies in progress in connection with current AEC activities should identify any unique species or races that may be encountered.

Most of the islands of the Refuge are mountainous, some with peaks rising to over 9,000 feet. A number of these peaks are still active volcanoes. By contrast, Amchitka is relatively low and flat. A section of high ridge country in the northwestern portion of the island has a few summits slightly over 1,100 feet high, but some two-thirds of the island surface has an elevation of less than 325 feet.

Amchitka, approximately 40 miles long and 3 to 5 miles wide, is oriented in a northwest-southeast direction. It has a total area of about 73,000 acres, out of the total of over 2.7 million acres in the nearly 70 named islands of the Refuge.

MAN ON AMCHITKA

Prehistoric Period

A systematic survey of Amchitka by professional archaeologists in 1967-1969, has disclosed nearly 80 archaeological sites, most of them prehistoric. Vandalism by souvenir-hunting American troops during World War II greatly complicated the task of the investigators in establishing the sequence of prehistoric human occupation of Amchitka.

Test excavations were made in a number of sites in 1968 and six sites were explored more thoroughly in 1969. Radiocarbon dating of bone and charcoal obtained from one site gave ages ranging from 890±90 to 2,550±95 years. Not enough work has been done to definitively establish the date of the earliest aboriginal occupation of Amchitka, but Desautels, et al. (1970) suggest that initial occupation took place "under 3,000 years" ago.

All of Amchitka's recorded archaeological sites are located along the coast; most are refuse middens largely of the shell and bone remains of fish, shellfish, birds, and marine mammals eaten by the aboriginal inhabitants. The sites are recognizable by their lush cover of vegetation, probably owing to the higher nutrient content of the soil and the better drainage afforded by the mound-like character of the middens.

Aside from the traces left at the occupied sites scattered along the coastline, the prehistoric inhabitants of Amchitka probably had little or no significant ecological impact on the island.

Historic Period

The Aleutian Chain was discovered in 1741 by the second Russian expedition under the command of Captain Vitus Bering. Georg Steller, the German naturalist with Bering's second expedition, took back to Russia extensive collections of plants and animals, including specimens of sea otters and fur seals. The subsequent unregulated exploitation of these valuable fur resources nearly extirpated the sea otters and fur seals and, indirectly, the Aleutian aborigines as well.

Desautels, et al. (1970) speculate, on the basis of another source (Coxe, 1803), that Amchitka was first visited by the Russian fur hunters in 1753. An FWS source indicates that the last permanent settlement on Amchitka was abandoned in 1849, although there was intermittent occupation of a few sites on the island thereafter, up to about the time of the Japanese occupation of Attu and Kiska in 1942.

Recent events significantly influencing the wildlife of Amchitka and, in some instances, substantially changing its landscape include the following:

1911. An international convention regulating taking of fur seals and prohibiting killing of sea otters was enacted. Amchitka is believed to have had a remnant sea otter population of perhaps 100 animals when the species was placed under protection (Kenyon, 1969).

1913. Executive Order 1733 established the Aleutian Islands Reservation, later to become the Aleutian Islands National Wildlife Refuge, with the stipulation that "the establishment of this reservation shall not interfere with the use of the islands for lighthouse, military, or naval purposes". Amchitka was included in the "Reservation".

1921. Blue foxes were introduced onto Amchitka, under a fur-farming lease agreement with natives from Atka Island. Foxes were harvested by the Atka villagers at least through 1936. That six annual harvests reported (from 1928-1936) yielded an average of 626 skins per year suggests that the fox population was considerable. An unpublished FWS source estimated that the fox population may have been as high as 4,000 at one time.

1943-1950. Amchitka was occupied by U. S. military forces. Estimates of peak troop strength on the island vary widely (3,000-25,000). Regardless of the number of troops stationed there, the military occupation left a lasting mark on the landscape, particularly on the southeastern half of the island. Three airstrips were constructed near Constantine Harbor, many miles of roads were built (including one extending the length of the island), and many hundreds of quonset huts and other buildings were erected. These structures were abandoned when military occupation ended in 1950.

The Norway rat was reportedly introduced during the military occupation (Murie, 1959). The rat population apparently built up rapidly, with disastrous consequences for some species of birds that had formerly nested on the island. Kenyon (1961) concluded, from studies conducted between 1955 and 1959, that ". . . the rat has exterminated two nesting species on Amchitka, the Song Sparrow (*Melospiza melodia maxima*) and the Winter Wren (*Troglodytes troglodytes kiskensis*)." (Recent studies show that Amchitka has a sizeable breeding population of winter wrens, and that a few pairs of song sparrows breed on nearby islets. These species either were not extirpated, as believed earlier, or have become reestablished.)

1951-1957. A fox and rat eradication program was carried out by the FWS, using strychnine and "1080". Foxes were eradicated and the rat population reduced. Feral dogs and cats abandoned on the island at the end of military occupation were also eradicated. The bald eagle population is reported to have declined somewhat during the period of intensive predator poisoning, but had apparently recovered by 1959 (Kenyon, 1961).

1958-1959. A "White Alice" station was constructed and operated by Western Electric Company for the Department of Defense.

1962. A program of controlled harvesting of sea otters was initiated by the Alaska Department of Fish and Game (ADF&G).

October, 1965. Project Long Shot, a Department of Defense underground nuclear test of about 80-kiloton yield, was carried out with AEC assistance. A "Bioenvironmental Safety" study was conducted by the University of Washington (Seymour and Nakatani, 1967).

1967. Construction activities and bioenvironmental studies in preparation for further underground nuclear testing were initiated by the AEC and its contractors.

October, 1969. Project Milrow was carried out by the AEC as a "calibration" test to determine the feasibility of safely conducting a test of somewhat higher yield. The bioenvironmental effects of Milrow are discussed below.

FISH AND WILDLIFE RESOURCES AND TERRAIN FEATURES OF AMCHITKA

It is not the intent of this Summary to attempt a detailed description of the natural history of Amchitka. Instead, some of the more significant features of the island, which are of particular concern to the public and to the scientific community because of their rarity, their special interest to science, or because of their economic importance, have been selected for discussion. To the extent possible at this time, the impact - or potential impact - of AEC activities on these features is also discussed.

Sea Otter (*Enhydra lutris*)

By 1911 the sea otter was nearly extinct in the North Pacific Ocean and Bering Sea, as a result of intensive and unregulated fur hunting by the Russians and, later, by the Americans. The otter was placed under protection in 1911 by an international convention subscribed to by the United States, Great Britain, Japan, and Russia. Under protection, there was a gradual recovery of the otter populations starting from small remnant groups that had escaped the fur hunters. One such group apparently survived on Amchitka.

Kenyon (1969) estimates that the Amchitka sea otter population may have been about 100 in 1910-11, increasing at the rate of about 10 percent per year to a peak population of about 4,500 in the early 1940's. Then there was a sharp decline, probably due to depletion of food supplies. The population reportedly fluctuated between 1,500-2,500 thereafter, until 1965 (the last estimate reported by Kenyon). Kenyon estimated that the total Alaskan sea otter population in 1965 was about 24,000, with the heaviest concentrations in the Andreanof and Rat Island groups; Amchitka is part of the latter group.

Helicopter support available in connection with AEC activities on Amchitka has made it feasible to conduct both visual and photographic censuses of the sea otter population. A visual count made by FWS biologists in 1968 led to a population estimate of 3,170 sea otters (Spencer, 1969). An unpublished 1969 count by FWS personnel gave an estimate of 3,630. A photographic/visual census made in 1969 yielded a population estimate of 2,800 (Stephan, 1971). The photographic/visual census estimate for 1970 indicated a population of about 3,300. Differences between estimates derived by different methods are not unexpected, in view of the difficulty of counting otters in the marine environment under generally unfavorable weather conditions. The estimates do, however, suggest that during the period 1968-1970 the Amchitka sea otter population is not declining, and may in fact be increasing.

Alaska Department of Fish and Game (ADF&G) personnel began harvesting sea otters from the Amchitka population in 1962. Harvests by ADF&G reported to date are: 1962 - 180 animals; 1963 - 311 animals; 1967 - 205 animals; 1970 - 205 animals. The furs collected from the early harvests were sold to commercial furriers at an auction held early in 1968.

Many habitats within the former range of the sea otter (e.g., the coasts of southeastern Alaska, British Columbia, Oregon, and Washington) are too far from present-day populations to be colonized by natural immigration of the animals. An obvious solution would be to move groups of animals to these habitats from other areas. Attempts to transplant otters from Amchitka to other habitats were started in 1951 by FWS biologists, in the hope that transplanted colonies would survive and become established as breeding populations, to serve as new dispersion centers from which the animals could move out and occupy more and more of their original range. In time, the sea otter might thus be restored to much of the extensive range it occupied before unregulated hunting led to its near extermination.

Early transplant attempts failed, but seven animals were successfully transplanted in 1959. These animals were removed from Amchitka to St. Paul Island in the Pribilofs; at least some of them are reported to have survived for 2 years. Kenyon (1969) speculated that this attempt ultimately failed either because the number transplanted was too small to form a viable colony, or because the habitat may have been marginal since it was at the northern limits of the original range of the species. Subsequently, the ADF&G carried out what were believed to be successful transplants of larger groups of otters in 1965 and 1966, although these animals were not captured at Amchitka.

Methods of capture and handling have been improved, and in 1968 AEC cooperated with the FWS by providing logistic support for air transport of a total of 359 animals to six locations in southeastern Alaska, and one location in the Pribilof Islands. A similar transplanting operation was supported by AEC in 1969. The 1969 transplant, totaling 116 animals, included one location each in southeastern Alaska, Washington, and British Columbia, plus the delivery of 4 animals to the Point Defiance Aquarium, Tacoma, Washington. A single male sea otter had been brought to the aquarium by Karl Kenyon, a BSF&W biologist, in 1965. The acquisition of the additional animals will permit further studies of the species in captivity. In 1970, 59 more animals were transplanted from Amchitka, 30 to the Washington coast and 29 to the coast of Oregon.*

During the period 1967 through July, 1970 nearly 1,250 sea otters have been taken from Amchitka, in transplants (including losses during capture and handling), harvests, and for experimental use. Despite this substantial removal of animals from the population, there has been no evidence of a decline in the total island population.

Other Marine Mammals

Amchitka has small resident populations of Steller's sea lion (recently estimated at about 750) and harbor seal (estimated to total about 350). These estimates were made July, 1968, by FWS biologists. Fur seals migrate past the island but are not known to come ashore unless sick or injured. There is no reason to expect there has been or will be adverse effects of the AEC operations on any of these populations.

Five species of whales are hunted by Japanese and Russian whaling fleets operating on both sides of the Aleutian Chain. Whaling grounds vary from year to year, and in some years whaling operations occur in the Bering Sea and North Pacific Ocean off Amchitka. Major catches in the western Aleutians are made during May through August. No adverse effects on the whale fisheries are expected from AEC testing on Amchitka.

Birds

Eighty-nine species of birds (including residents, migrants and accidentals) were recorded on Amchitka by ornithologists from August, 1967 through June, 1970 (Williamson, et al., 1971). An additional 11 species reported by Kenyon (1961) have not been seen during the recent study period. Nearly half of these 100 species are infrequent visitors or accidentals; only 27 species were found to breed on the island during the 1969 nesting season. The following species are of special interest, for one reason or another:

Bald Eagle (*Haliaeetus leucocephalus*): The southern race of the bald eagle is listed as "endangered" by the U. S. Department of the Interior (USDI, 1968). However, the northern race is not so listed. A USDI leaflet (1963) lists the bald eagle as "common" in the Aleutian Islands National Wildlife Refuge as a whole.

The resident population of bald eagles on Amchitka is currently estimated at about 200, including 55 breeding pairs. Nests are characteristically on the tops of "sea stacks", isolated pinnacles of rock cut off from the mainland by wave erosion. Less

*The USAEC DRAFT ENVIRONMENTAL STATEMENT - CANNIKIN, June 12, 1970, comments on the sea otter transplants as follows: "The AEC is supporting the sea otter transplant from Amchitka because support facilities and rapid air transportation are available and this assistance can be furnished ADF&G without interfering with AEC operations, or incurring significant additional expense. The support is not being provided because there is apprehension that the Amchitka otter population will be significantly affected by the proposed underground nuclear tests."

commonly nests are placed on the edges of the sea cliffs. No adverse effects of AEC operations (including Milrow) on the bald eagle population have been observed. Milrow was conducted in October. Since nesting of the bald eagle is essentially complete by the end of July, no eggs or nestlings were on nests at the time of the detonation. No sea stack or sea cliff nesting sites utilized by bald eagles were destroyed by ground motion from Milrow.

Peregrine Falcon (*Falco peregrinus*): This species is considered as "endangered" throughout its range (USDI, 1968). Thus, the Amchitka resident population of peregrines has received special attention in the avian ecology studies. During 1970, 12-14 eyries were occupied by nesting pairs. Fledging success was not determined in 1970, but in 1969 fledging success for 11 eyries where nesting attempts were known averaged 1.36 young per nest (White, et al., 1970).

The worldwide decline in peregrine populations has been attributed, in part, to cumulative effects of pesticides, especially chlorinated hydrocarbons. These compounds are believed to be responsible for eggshell thinning, which in turn leads to increased breakage of eggs and lowered reproductive success. White, et al. (1971) have reported on the DDE* content of Amchitka peregrine falcon eggs, and on the DDE content of a number of species of birds preyed upon by the peregrines. The eggs of Amchitka peregrine falcons are substantially lower in DDE content than those from southwestern Canadian islands where the peregrine prey species are similar to those at Amchitka. Nevertheless, these authors find evidence that shell thickness of Amchitka falcon eggs is significantly less than that of comparable eggs collected before use of chlorinated hydrocarbon pesticides began. Amchitka peregrine eggs are also being analyzed for PCB**. The sources of the DDE and PCB found in falcon eggs from Amchitka, and the routes of dispersal to this remote location, are as yet undetermined, but their existence in the Amchitka ecosystem is believed to be unrelated to AEC activities on the island.

No falcon eyries were destroyed by Milrow, and, since this test was conducted after the nesting season, no eggs or nestlings were affected. There is no evidence that other AEC activities on the island have had any direct effects on the resident peregrine falcon population.

Emperor Goose (*Philacte canagica*): This is the most abundant overwintering species on Amchitka, appearing in small numbers as early as September, and reaching an estimated peak population of about 5,000 individuals by midwinter.*** The breeding habitats of the Amchitka wintering population are not known. The nearest known breeding area for this species is in northeastern Siberia, but this is only slightly nearer than a known breeding area in western Alaska. There is no reason to expect that a contained nuclear test on Amchitka would adversely affect the emperor goose wintering population.

Winter Wren (*Troglodytes troglodytes*): This species was considered by Kenyon (1961) to have been extirpated from Amchitka; predation by rats was thought to be the probable cause. Recent studies sponsored by AEC report an estimated resident population

*A major metabolite of DDT.

**Polychlorinated biphenyls - industrial chemicals used in plastics and some rubbers - which are known to have biochemical effects similar to those of the hydrocarbon pesticides and their metabolites.

***An earlier issue of this Summary, released in 1969, gave an estimated peak wintering population of 12,000, based on earlier observations by Smithsonian ornithologists. The present estimate, based on observations made in the winter of 1969-70 with the aid of a helicopter, is believed to be more realistic.

of about 1,000 individuals. The proposed nuclear testing and related AEC activities are not expected to adversely affect the winter wren population.

Song Sparrow (*Melospiza melodia*): This species appears to be rare on Amchitka proper, owing to rat predation; it breeds on offshore islets which have no rats. It was estimated that there were about 10 breeding pairs in the 1969 nesting season (Williamson, et al., 1971). The species is listed as abundant in the Aleutian refuge as a whole (USDI, 1963).

Aleutian Canada Goose (*Branta canadensis leucopareia*): This race, described by USDI as "endangered", is reported to breed only on Buldir Island, some 120 miles northwest of Amchitka; it is believed to have been extirpated from other Aleutian Islands as a nesting species by predation by introduced foxes, and possibly by rats. USDI has considered Amchitka, among several other islands, as suitable for reestablishment of breeding populations of this rare race of Canada goose, which once bred on Amchitka and several other Aleutian Islands. Plans to attempt reintroduction of this species were recently executed. A colony of 75 birds from the Patuxent Wildlife Research Center was transplanted to Amchitka early in March, 1971, using AEC logistic support to transport the birds. These birds are descendants of 5 pairs of birds obtained as goslings on Buldir Island in 1963.

Fish

Dolly Varden (*Salvelinus malma*) are found in most of the freshwater streams of any size, and in many of the lakes, on Amchitka. There appear to be two populations - resident and sea-run. This is the only species that can be considered a freshwater sport fish on the island.

Three species of Pacific salmon (*Oncorhynchus* spp.) spawn in freshwater streams on Amchitka. Earlier investigations had indicated that there were only about seven or eight salmon-spawning streams on the island. However, a more thorough survey of potential spawning streams, made in the summer and early fall of 1970 when helicopter support was available, identified 21 streams in which pink salmon (*O. gorbuscha*) spawned. Coho salmon (*O. kisutch*) were observed in 5 of these streams (Neuhold, et al., 1970). Sockeye salmon (*O. nerka*) have been seen only infrequently during the studies started in 1967. Salmon runs on Amchitka are relatively small, and their contribution to commercial fisheries stocks can be considered negligible compared to that of streams on the Asiatic and North American mainlands.

The principal commercial fishing carried out near Amchitka is the Japanese high-seas salmon fishery from mid-May through early August. Adult salmon caught by the Japanese off Amchitka during this time are migrating through the area to spawning streams on the Asian or North American mainland. Immature salmon, which make up part of the Japanese high seas catch, are also passing the Aleutians during their seasonal movement. Apparently neither adults nor immatures spend much time near the island during these migration movements.

Alaskan salmon fishing is carried out in coastal waters, at or near the mouths of streams to which the fish are returning to spawn. Thus, the Alaskan salmon harvested are taken at locations far to the east of Amchitka. The Alaskan salmon fishery starts in June, reaches a peak in July, and lasts until September.

At present there is no king crab fishery near Amchitka, and exploratory fishing has not established whether the king crab stock in the area is sufficient to support commercial fishing. The Japanese and Russians fish for king crab in the eastern Bering Sea, while the Alaskan crab fishery is carried on in the Gulf of Alaska, on both sides of the Alaskan Peninsula, and near the eastern Aleutians. These salmon and king crab fishing

grounds are sufficiently distant from Amchitka that the AEC underground tests on the island are not expected to influence these fisheries.

Some Russian and Japanese fishing vessels may operate in the general vicinity of the western Aleutians during summer and early fall, fishing for Pacific ocean perch (*Sebastes alutus*), Pacific halibut (*Hippoglossus stenolepis*), and other bottom fish. This fishing activity usually declines markedly after September. These fisheries are generally conducted in deep water (50-500 fathoms), mainly in the Pacific, west of Amchitka. Exploratory trawl fishing conducted during the late summer and early fall of 1970 produced no significant catches of Pacific ocean perch or other bottom fishes on the Pacific Ocean side of Amchitka at depths less than 100 fathoms. There was a marked movement of Pacific ocean perch to deeper water, i.e., to depths of 300-400 fathoms or more, during September. Bottom trawling produced no large catches of commercial species in the Bering Sea off Amchitka, and bottom conditions were found to be unfavorable for trawling (Burgner, et al., 1971).

Soils and Vegetation

The soils and vegetative cover of Amchitka vary widely from area to area, depending largely on topography, elevation and drainage characteristics. The southeastern half of the island, where the AEC nuclear testing is being conducted, is a plateau of relatively low relief and poor drainage dotted with many hundreds of shallow lakes and ponds, ranging from a fraction of an acre to nearly 70 acres in area, and 3-6 feet deep. Elevations in this portion of the island generally range from about 125 to 275 feet, although higher elevations are found at a few points.

Much of this lowland section is covered with a maritime tundra vegetation, consisting mainly of lichens, mosses, sedges, grasses, and subshrubs such as crowberry. Permafrost is absent. The mat of living vegetation is in many areas thin and easily disrupted. In poorly drained areas the vegetation is underlain by several feet or more of spongy, partially decomposed peat that offers little support for off-road vehicular traffic. Once the living vegetation is depressed into the peat layer by the weight of a vehicle it dies, and revegetation of such tracks may be extremely slow. Vehicle tracks across the tundra made during World War II are still visible in many places. On some slopes they have eroded entirely through the organic layer to rock substrate. On disturbed areas with reasonably good drainage, and especially where some mineral soil is present, e.g., along graded roadways, natural revegetaion by a native lupine and certain species of native grasses can occur.

The northwestern half of the island is mountainous, with summits up to 1,100 feet high or more, grading into a high plateau region with elevations of 700-800 feet at the northwestern end of the island. At higher elevations, deposits of peat are either absent or very thin. Vegetation grades from nearly continuous cover by upland meadow to patchy clumps of prostrate dwarf willow-crowberry, interspersed with large areas of bare gravel or small boulders.

Certain soils of the islands are naturally unstable and tend to move gradually downslope, whether disturbed or not. Unstable solifluction terraces on basal mineral soil and rock substrate are found in the higher parts of the island. In the lowland section where peat deposits have built up to considerable depths on moderate to steep slopes, instability may be due to the presence of a natural slippage plane between the peat layer and the mineral substrate. Overloading of such soils on sloping terrain can lead to massive soil and peat slides. Such a slide occurred in one stream valley where drilling wastes were stored in sump pits on unstable soil at the head of the valley. The effects of this slide are discussed later.

AMCHITKA BIOENVIRONMENTAL PROGRAM

Under contract with AEC Nevada Operations Office, Battelle's Columbus Laboratories initiated ecological studies on Amchitka early in 1967. The investigations are being carried out with the assistance of scientists from several universities, the Smithsonian Institution, the U. S. Fish and Wildlife Service, and the National Marine Fisheries Service. The bioenvironmental studies are designed to: (1) predict, document, and evaluate the effects of AEC testing activities on the biota and the environment; (2) recommend measures for minimizing adverse effects; and (3) predict and evaluate the dispersion of radionuclides in the marine environment and their potential transport to man via marine food chains, should there be an inadvertent release.

The program includes studies of soils, vegetation, biota of freshwater streams and lakes, birds, and marine flora and fauna, including some exploratory fishing. An annual sea otter census is being conducted to assess population trends. Laboratory studies on the response of sea otters to underwater overpressure pulses were conducted early in the program. Presently, a field study of sea otter behavior is in progress to provide additional data for predicting possible effects of the proposed Cannikin test on the Amchitka otter population. Models have also been developed for making conservative predictions of the dispersion of any radionuclides that might inadvertently be released into the marine ecosystem around Amchitka, and their transport to man by marine food chains.*

The present bioenvironmental studies, when completed, are expected to add materially to our basic understanding of the ecosystems of this remote island. In addition to the 30 AEC reports covering these studies, published to date by Battelle's Columbus Laboratories, some 25 journal articles on the bioenvironment of Amchitka and the surrounding ocean waters have been published, or are in preparation for publication. Many of these were presented at a special symposium sponsored by the Ecological Society of America, held in conjunction with the 21st Annual Meeting of the American Institute of Biological Sciences, August 26-27, 1970.** Six graduate theses have been prepared on the basis of work carried out as part of the bioenvironmental studies program, and it is anticipated that additional theses will be developed on the program before it is completed. Much of the material contained in this Summary is derived from the reports and other publications mentioned above.

AEC COOPERATION WITH FEDERAL RESOURCE AGENCIES

To assist the U. S. Fish and Wildlife Service in carrying out its functions on Amchitka as custodian of the Aleutian Islands National Refuge, AEC provided funds making it possible for the FWS to assign two Refuge Management Biologists and two Research Biologists to participate in the Amchitka operations and investigations. The FWS Management Biologists are responsible for surveillance of the island at all times. Their primary function is to advise AEC engineering and construction personnel on measures for minimizing disturbance of the ecosystem and for preserving Refuge values.

With the implementation of recent organizational changes in the Federal Government, the two Research Biologists assigned to the Amchitka program now represent, respectively, the Department of the Interior, Fish and Wildlife Service, and the Department of Commerce, National Marine Fisheries Service (NMFS). The role of these representatives is to maintain technical liaison between their respective agencies, AEC Nevada Operations

*The USAEC DRAFT ENVIRONMENTAL STATEMENT - CANNIKIN, June 12, 1970, states: "The CANNIKIN test is designed to retain activity completely underground and the chance of prompt release of radioactivity to the biosphere is remote."

**The complete series of papers presented at this symposium will appear in a special edition of the journal, BioScience, scheduled for publication in June, 1971.

office, and Battelle's Columbus Laboratories on matters pertaining to the bioenvironmental studies program.

In addition to providing for the services of the above-mentioned liaison and advisory personnel, AEC is supporting an NMFS study by marine scuba diver biologists on the distribution and abundance of sea urchins in nearshore waters off Amchitka. The Bureau of Commercial Fisheries (now NMFS), Seattle Biological Laboratory, was also funded to conduct a 6-week oceanographic cruise near Amchitka during the winter of 1967. Valuable new data on the oceanography of the North Pacific Ocean and southern Bering Sea were collected.

BIOENVIRONMENTAL EFFECTS EVALUATION

Throughout the progress of the Amchitka bioenvironmental program attention has been given to assessing the impact of AEC activities, both nuclear testing per se, and field operations required to support the testing, on the Amchitka ecosystems. A special program of testtime experiments and observations was carried out in conjunction with Milrow to evaluate the effects of that test and to provide a basis for predicting the potential effects of a subsequent higher yield test.

Prior to Milrow, bioenvironmental base lines were documented in the terrestrial, freshwater and marine ecosystems. Postshot studies began soon after the Milrow test to identify and assess prompt effects. Investigations are continuing, to evaluate any bioenvironmental effects that may not have been detected in the early postshot period.

Several experiments were conducted during the Milrow shot to obtain biological response data to aid in assessing the effects of Milrow, and to be used in scaling up predictions of biological effects that might be expected from future tests of greater yield. In these experiments, sea otters, freshwater fish, ocean fish, and crabs were placed in holding pens in their natural habitats, to study their reaction to and survival of shock effects of Milrow. Following the detonation, survey parties of biologists, including representatives of the U. S. Fish and Wildlife Service, reconnoitered the area surrounding the Milrow test site by helicopter, boat, and on foot to search for any dead or injured fish, marine mammals, or birds. These surveys commenced a few hours after the shot and continued for several days.

Effects of Milrow

The prompt effects of Milrow on the Amchitka bioenvironment are discussed by Kirkwood (1970) and by Merritt (1970), based on reports from all investigators participating in the field studies. The prompt effects were minimal. Summarized here are the principal effects detected during the early post-Milrow period:

(1) Two small lakes near SZ (surface zero) were partially drained upon formation of a shallow subsidence crater around SZ (a depression about 1,000 feet in radius and 15 feet deep at its lowest point).

(2) A few lakes and streams exhibited changes in water level or stream flow rates and there was a marked decrease in zooplankton in a sifngle lake soon after the test.

(3) Numerous threespine sticklebacks (*Gasterosteus aculeatus*) - small freshwater fish widely distributed in the lakes and streams of the island - were killed in two lakes, 1,650-3,050 feet from SZ, possibly due to abrupt pressure change with passage of the shock wave. However, in neither lake was the entire stickleback population destroyed, so ultimate recovery of the populations in these lakes is anticipated.

Shottime experiments with Dolly Varden and salmon confined in holding pens in lakes and streams near SZ demonstrated that these species were not affected by shock forces from the detonation.

(4) A few dead marine fish were observed in the inshore waters during early post-Milrow overflights, but no evidence was found that any marine fish populations were significantly affected by Milrow. Fish and crabs confined in live boxes during the Milrow test were found to be unaffected when recovered after the test.

Pre- and post-Milrow sampling of populations of bottom-dwelling sea urchins (*Strongylocentrotus* sp.) at Bering Sea and Pacific Ocean sites near SZ indicated that these invertebrate populations were unaffected by Milrow.

(Some die-off of algae was noted on the shallow intertidal bench along a short section of Pacific Ocean shoreline near Milrow SZ, during a survey made about 6 months post-Milrow. A part of the inshore marine terrace had been lifted vertically a few inches on one side of a pre-existing fault, which was enough to affect some of the algae in this zone. Ultimate establishment of an algal cover is anticipated.)

(5) One sea otter confined in a floating test pen in the Pacific, 9,200 feet from Milrow SZ, was found dead after the test. Necropsy of the animal revealed nothing identifiable as a test-related cause of death; in fact, cause of death could not be determined. Twenty-two additional otters in test pens survived without apparent harm. One of these test pens was located on the Pacific shore, 4,300 feet from SZ.

One dead porpoise was found near the Bering seashore about 2 miles from SZ. This animal had a fractured rib that had penetrated the lung, causing death. Cause of the fracture could not be determined.

(6) No adverse effects of Milrow on the bird populations of Amchitka were detected.

(7) Rock and turf falls totaling nearly 14,000 cubic yards of material occurred along the coasts opposite Milrow SZ. The largest rock fall took place on the Bering Sea coast, in a cliff area that had apparently been subject to large natural rock falls during past years. No eagle nests or peregrine falcon eyries were destroyed.

(8) No prompt changes in terrestrial vegetation communities were expected, and none were found. It is anticipated that any such changes that occur will come about slowly, as a result of changes in drainage patterns resulting from surface subsidence or from fracturing of the peat blanket.

(9) A few "moss mounds" within 1,500 yards of SZ were explosively destroyed, presumably as a result of a sudden increase in hydrostatic pressure with passage of the ground shock wave.

(10) Radiation-monitoring programs conducted by other project participants have not detected any release of radioactivity from Milrow.

From this listing it is clear that the early bioenvironmental effects of Milrow that have been identified and documented are relatively few. These effects resulted from the shock of the explosion transmitted through the ground and water, and from subsequent earth movements. Most of the effects occurred within a radius of about 2.5 miles from SZ. Some of them, e.g., the partial draining of lakes near Milrow SZ and the cracking of the lake bottoms and tundra near SZ, would be evident to anyone viewing the site. Other effects, such as reduction of stickleback populations in two lakes near SZ, were obvious only during the early posttest studies. Field studies continue in order to determine how rapidly these populations recover. Studies conducted to date have not produced evidence that any of the island's ecosystems has been significantly altered by the Milrow test.

Effects of Operations and Site Preparation

The principal impact of AEC activities on Amchitka since 1966 has been that associated with construction, drilling, and other site preparations, and occupancy by as many as 700 men at peak periods.

Road construction and improvement have generally adhered closely to the road network laid out during World War II. Fresh grading, and quarrying and distribution of road gravel have resulted in some siltation of lakes and streams. The ecological significance, if any, of this disturbance has not yet been evaluated.

Several spills or leaks of drilling liquids have resulted in the pollution of some lakes and sections of streams, with the consequent death of biota in the polluted waters. In one stream valley a mud slide, triggered by overloading of drilling mud sumps at the drill site near the head of the stream, flowed all the way to the mouth of the stream - a distance of over 2,000 yards. A FWS biologist stationed on Amchitka estimated in July, 1969 that a total of about 10.5 miles of stream channels and about 70 acres of lake had been polluted by site preparation and construction activities, mostly from drilling mud spills or leaks. However, it should be noted that by the summer of 1970 several of the polluted streams were in the process of recovery, as evidenced by the presence of invertebrate bottom organisms, Dolly Varden, and spawning pink salmon.

Some 950 acres of terrestrial habitat were reported to have been disturbed by 1969, largely by road building and repairs, drilling and construction, and development of gravel-supply areas. About half of this represents new disturbance; the balance is on land previously disturbed by World War II occupation (Merritt, 1970).

It is anticipated that restoration of a certain part of the terrain disturbed by the AEC's use of Amchitka can be hastened by such measures as contouring and/or reseeding with selected species of grasses and possibly legumes. Plans for carrying out such restorative actions, where feasible, are presently under joint consideration by AEC and FWS. Technical assistance is being provided by specialists of the Alaska State Agricultural Experiment Station, Palmer, Alaska.

Cannikin

Discussions of Cannikin, the next nuclear test planned for fall 1971, are beyond the scope of this document. The reader is referred to the Cannikin "Environmental Statement", to be issued by the USAEC in spring 1971, for predictions of expected bioenvironmental effects from that test and for related information.

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